Effect of Silica Fume and Metakaoline in Consistency and Setting Time of OPC

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Abstract

Consistency and setting time is an important parameter of the harden concrete. The pulpous of this study is to compare the above mentioned parameter, as a partial replacement of cement with silica fume (SF)/metakaoline (MK) ranging from 0 to 15% at an interval of 2.5%. The normal consistency of cement (OPC) is 30.5% and for 15% SF replacement is 37% and for 15% MF replacement is 36.37% as the maximum values. It is inferred that increase in the replacement level of admixtures increases the water demand. The initial setting time (IST) and the final setting time (FST) for cement (OPC) replaced with 15% SF are 240 and 285 minutes and for 15% MK are 260 and 305 minutes respectively.

Keywords: Cement, Admixtures, Consistency, Setting Time

1. Introduction

Many large roman structures were made from lime mixed with natural pozzolana and crushed burnt clay, and some are still in use in today. During 18th century by 1759 Smeaton found he could make strong hydraulic cement by blending suitable lime stone and clay solids and then burning the mixture. This quickly leads to the development of an early form of Portland cements(PC) by Aspidin in 1826.In the 20th century pozzolanas were originally used to reduce the cost of PC.In1940's it was found that Pozzalana-PC concrete could prevent the occurrence of alkali silica reaction(ASR) and hence improve the durability of concrete.

Within the construction industry, the term pozzalana covers all the materials which react with the lime and water giving calcium silicate and acuminate hydrates possessing cementing properties. Silca Fume (SF) and Metakaoline (MK) are relatively a new material and an activated pozzalana which are used in this research. Condensed Silica Fume (CSF) is as the name indicates the condensation of oxidised silicon monoxide coming from gases of silicon or ferrosilicon smelter oven in addition to small dust particles. The material is highly pozzalonic but it hard to handle and it increases the water required in concrete appreciably. Metakaoline (MK) can be activated by alkali metal hydroxides by alkali metal silicates or by calcium hydroxide, which is one of the hydration products of PC. In this research the experiments were in order to evaluate the effect of CSF and MK in consistency and setting time of the PC.

2. Materials and Methods

The chemical composition of the SF, MK and OPC used in this study are conforming to IS specifications. OPC is replaced with SF and MK from 0 to 15% at an interval of 2.5%. The test method for Standard Consistency as specified by the IS: 4031 (Part 4) – 1988, and the initial and final setting time as per IS: 4031 (Part 5) – 1988. Vicat apparatus conforming to IS: 5513 – 1976.

3. Result and Discussion

3.1 Consistency

The normal consistency of OPC without any admixture is 30.5%, and for OPC replaced with 15% SF it is 37% and 15% MK it is 36.67% as the maximum value. The results were shown in **table 1**. Similarly by keeping the normal consistency of OPC as constant throughout the replacement levels, the percentage of chemical admixture required to attain the normal consistency is found out and shown in **table 2.** Were the chemical admixture required for OPC replaced with 15% SF it is 2.32% and 15% MK it is 1.68% as the maximum value. From the figure 1 and figure 2 it clearly shows that the consistency increases with increase in admixtures.

SF is finer than MK, because of this OPC with SF consumes more water as compare to OPC with MK for consistency.

Table 1: Normal consistency for OPC with SF and MK (0 to 15%)

Cement (gm)	*SF*		*Normal Consistency (%)*	*MK*		*Normal Consistency (%)*
	%	*gm*		*%*	*gm*	
300.0	*0*	*0.0*	*30.50*	*0*	*0.0*	*30.05*
292.5	*2.5*	*7.5*	*31.00*	*2.5*	*7.5*	*31.05*
285.0	*5.0*	*15.0*	*33.00*	*5.0*	*15.0*	*32.25*
277.5	*7.5*	*22.5*	*34.00*	*7.5*	*22.5*	*33.33*
270.0	*10*	*30.0*	*35.00*	*10*	*30.0*	*34.67*
262.5	*12.5*	*37.5*	*36.00*	*12.5*	*37.5*	*35.50*
255.0	*15*	*45*	*37.00*	*15*	*45*	*36.67*

Table 2: Chemical admixture required to attain the normal consistency of 30.50% for OPC with SF and MK (0 to 15%)

Cement (gm)	*SF gm*	*Chemical Admixtures*		*MK gm*	*Chemical Admixtures*	
		%	*ml*		*%*	*ml*
300.0	*0.0*	*0.00*	*0.0*	*0.0*	*0.00*	*0.0*
292.5	*7.5*	*0.80*	*2.0*	*7.5*	*0.24*	*0.6*
285.0	*15.0*	*1.12*	*2.8*	*15.0*	*0.40*	*1.0*
277.5	*22.5*	*1.44*	*3.6*	*22.5*	*0.60*	*1.5*
270.0	*30.0*	*1.76*	*4.4*	*30.0*	*0.88*	*2.2*
262.5	*37.5*	*2.00*	*5.0*	*37.5*	*1.40*	*3.5*
255.0	*45*	*2.32*	*5.8*	*45*	*1.68*	*4.2*

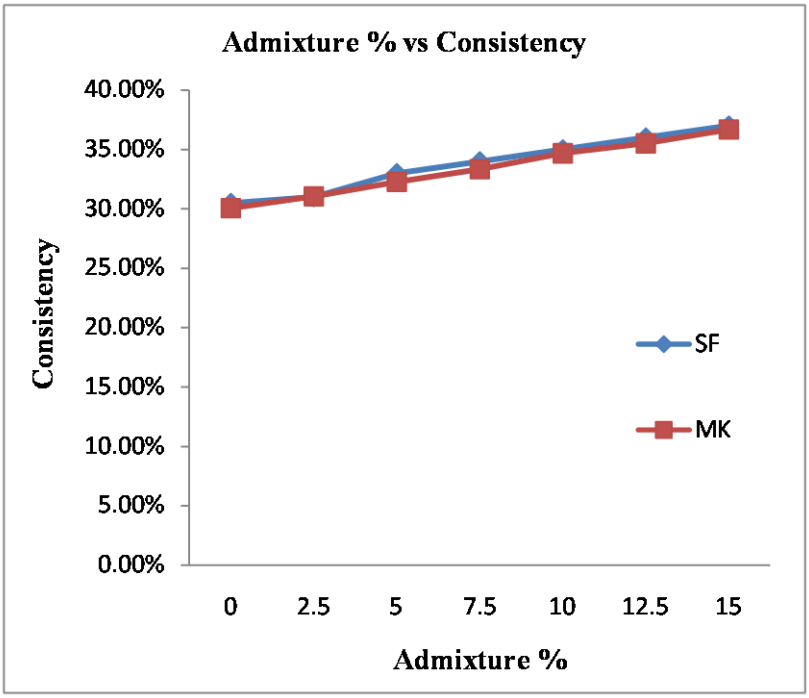

Figure 1: Admixtures% vs. Consistency

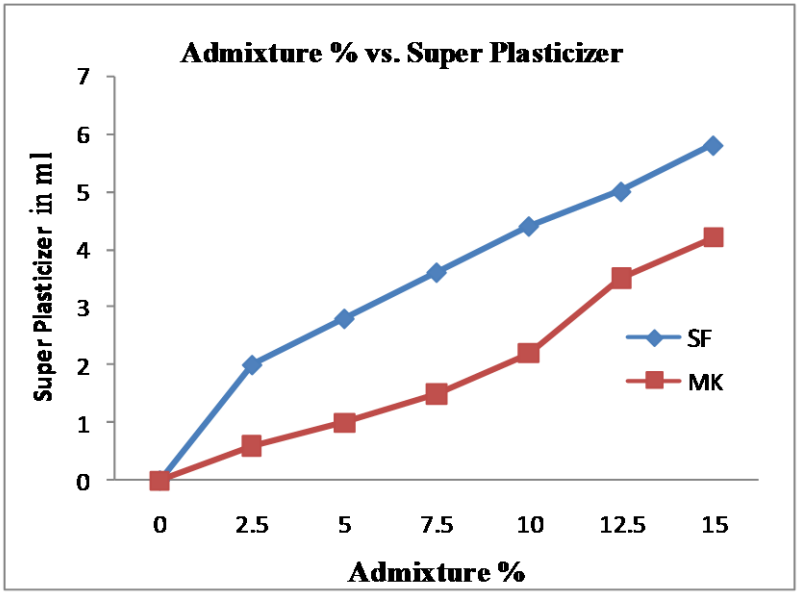

Figure 2: Admixture % vs. Super Plasticizer

3.2 Setting Time

The initial setting time (IST) and final setting time (FST) of OPC are 125 and 170 minutes, the IST and FST for OPC replaced with 15% SF are 340 and 405 minutes and 15% MK are 355 and 425 minutes as the maximum values. The results are tabulated in **table 3 and table 4.** The addition of chemical admixtures further increases the setting time, it is due to the presence of hydroxyl ions formed around in the cement paste.

Table 3: Initial and Final setting time (IST and FST) OPC with SF and MK (0 to 15%)

Cement gm	*SF %*	*IST min*	*FST min*	*MK %*	*IST min*	*FST min*
300.0	*0*	*125*	*170*	*0*	*125*	*170*
292.5	*2.5*	*135*	*180*	*2.5*	*140*	*185*
285.0	*5.0*	*145*	*195*	*5.0*	*150*	*205*
277.5	*7.5*	*170*	*225*	*7.5*	*170*	*230*
270.0	*10*	*205*	*250*	*10*	*210*	*255*
262.5	*12.5*	*230*	*270*	*12.5*	*240*	*280*
255.0	*15*	*240*	*285*	*15*	*260*	*305*

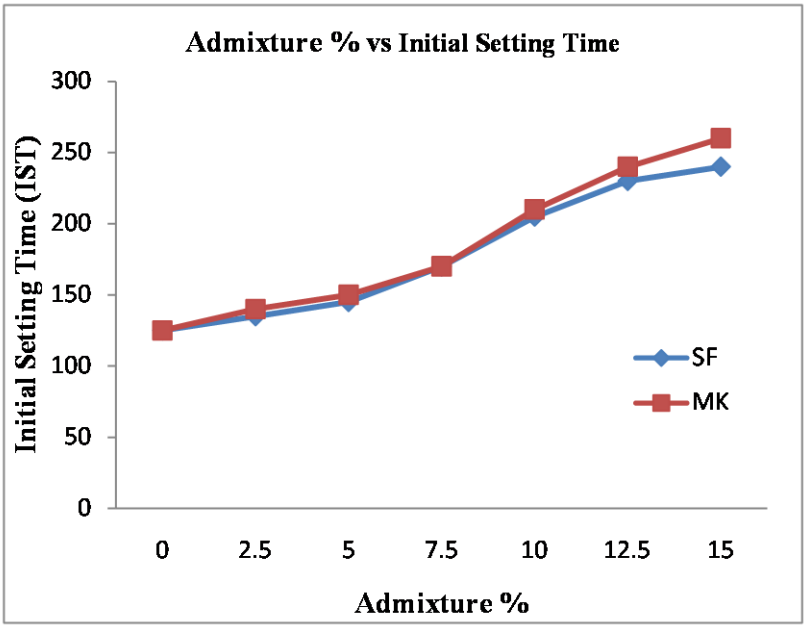

Figure 3: Admixture % vs. Initial Setting Time

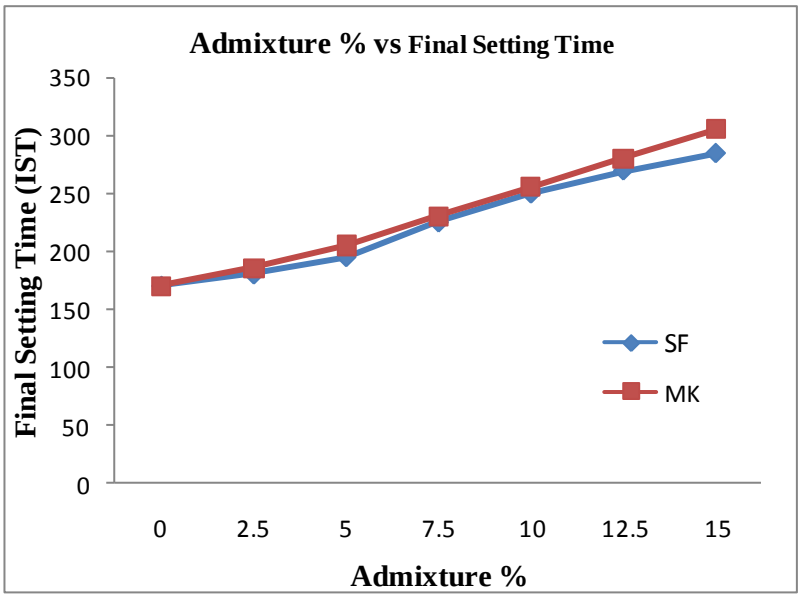

Figure 4: Admixture % vs. Final Setting Time

Table 4: Effect of Chemical Admixtures on Initial and Final setting time (IST and FST) OPC with SF and MK (0 to 15%)

Cement gm	*SF %*	*Chemical Admixtures*		*IST min*	*FST min*	*MK %*	*Chemical Admixtures*		*IST min*	*FST min*
		%	*ml*				*%*	*ml*		
300.0	*0*	*0.00*	*0.0*	*125*	*170*	*0*	*0.00*	*0.0*	*125*	*170*
292.5	*2.5*	*0.80*	*2.0*	*150*	*180*	*2.5*	*0.24*	*0.6*	*165*	*190*
285.0	*5.0*	*1.12*	*2.8*	*160*	*210*	*5.0*	*0.40*	*1.0*	*180*	*220*
277.5	*7.5*	*1.44*	*3.6*	*200*	*260*	*7.5*	*0.60*	*1.5*	*210*	*275*
270.0	*10*	*1.76*	*4.4*	*225*	*295*	*10*	*0.88*	*2.2*	*245*	*315*
262.5	*12.5*	*2.00*	*5.0*	*285*	*345*	*12.5*	*1.40*	*3.5*	*300*	*370*
255.0	*15*	*2.32*	*5.8*	*340*	*405*	*15*	*1.68*	*4.2*	*355*	*425*

4. Conclusions

The following conclusions are made based on the limitations of the test results,

The increase in water demand for consistency of OPC with SF and MK is because of extreme fineness. Also the percentage of chemical admixture (super plasticizer) increases with the addition of mineral admixture (SF and MK).

The initial and final setting time of OPC with SF and MK increases, when the percentage of SF and MK increases. And the addition of chemical admixture (super plasticizer) further increases the setting time.

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